Modularity of base station transceiver subsystem and distributed structure

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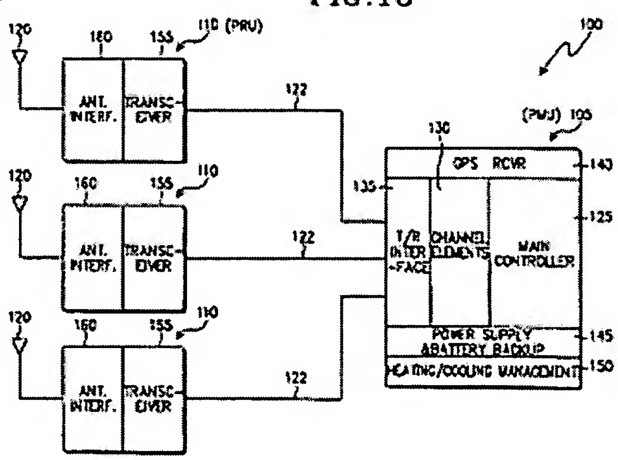
A base station transceiver system is divided into at least one remotely located radio unit 110 and a main unit 105. The main unit and radio units are connected together by coaxial cables 122, and communicate using IF or baseband signals which results in lower power losses through the cable than would be the case for higher frequency signals. The main unit comprises: a main controller 125 which may communicate with a base station controller, channel elements 130 for modulating and demodulating CDMA signals, a transmit/receive interface connected to the channel elements, GPS receiver 140 which provides accurate clock and frequency signals to the controller, as well as power supply 145 and temperature control subsystems 150. The radio units comprise transceiver circuitry 155, and antenna interfaces 160 which may include low noise amplifiers which provide amplified signals for the antennas 120.

FIG.13



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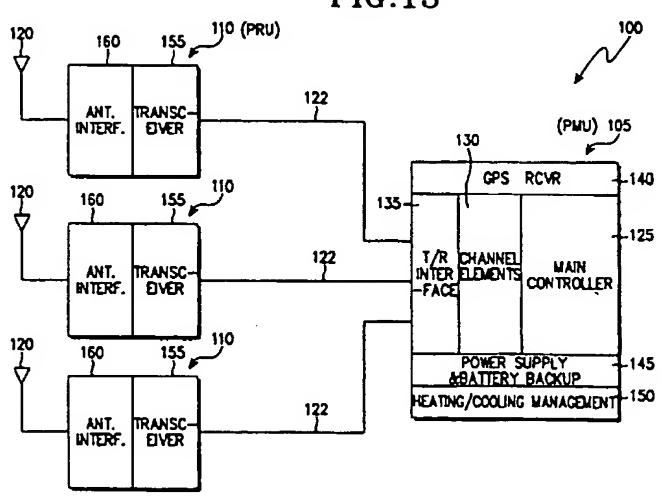
(54) Abstract Title
Base station transceiver subsystem

(57) A base station transceiver system is divided into at least one remotely located radio unit 110 and a main unit 105. The main unit and radio units are connected together by coaxial cables 122, and communicate using IF or baseband signals which results in lower power losses through the cable than would be the case for higher frequency signals. The main unit comprises: a main controller 125 which may communicate with a base station controller, channel elements 130 for modulating and demodulating CDMA signals, a transmit/receive interface connected to the channel elements, GPS receiver 140 which provides accurate clock and frequency signals to the controller, as well as power supply 145 and temperature control subsystems 150. The radio units comprise transceiver circuitry 155, and antenna interfaces 160 which may include low noise amplifiers which provide amplified signals for the antennas 120.

FIG.13



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

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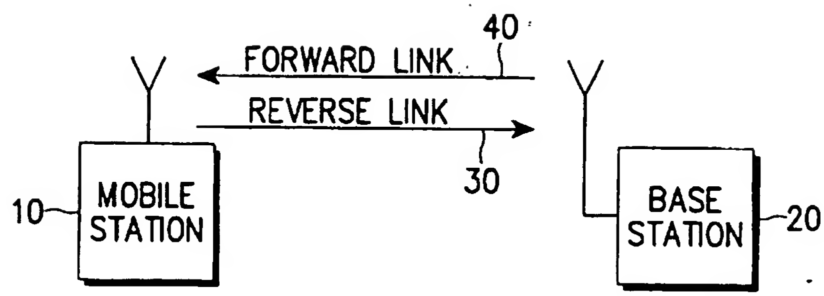
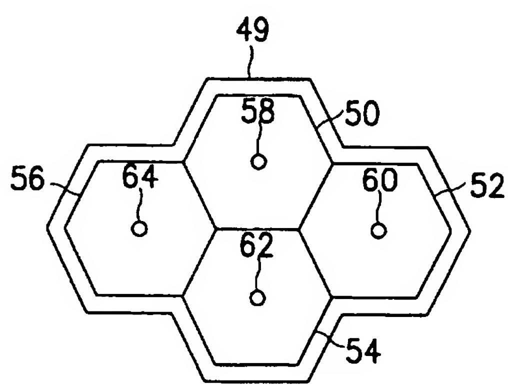


(PRIOR ART)
FIG.1



(PRIOR ART)
FIG.2

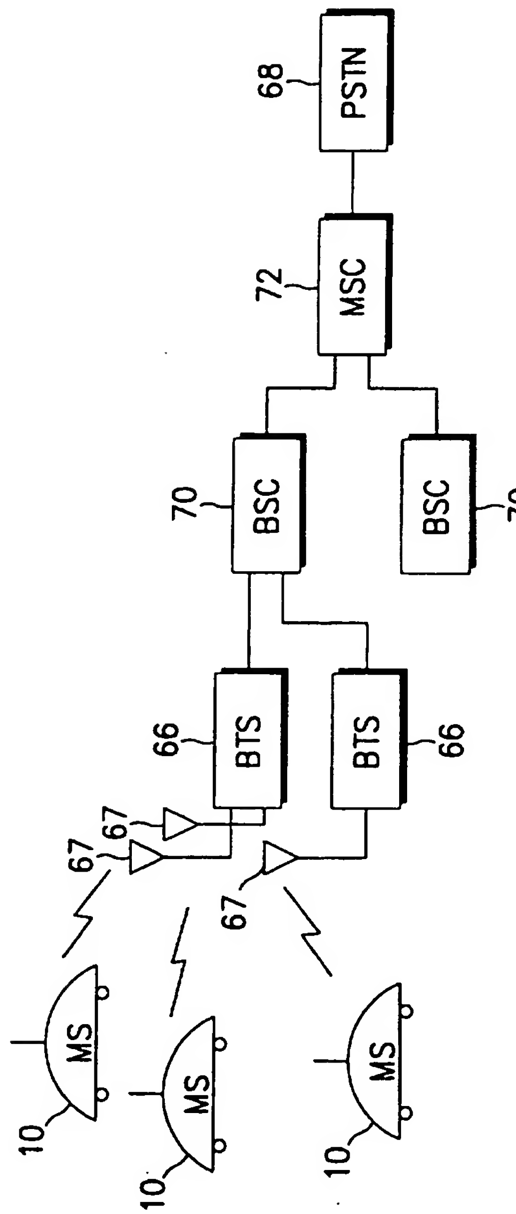
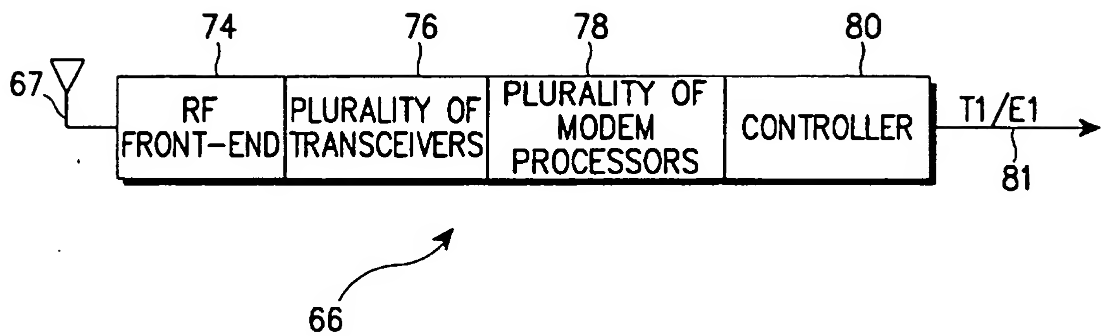
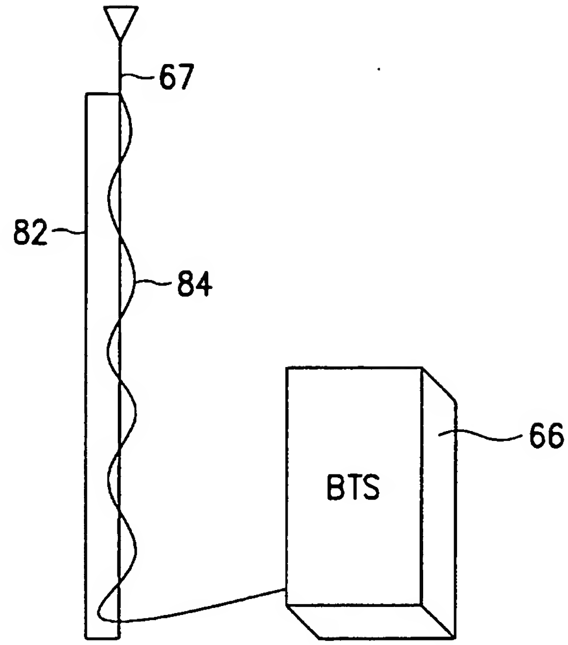


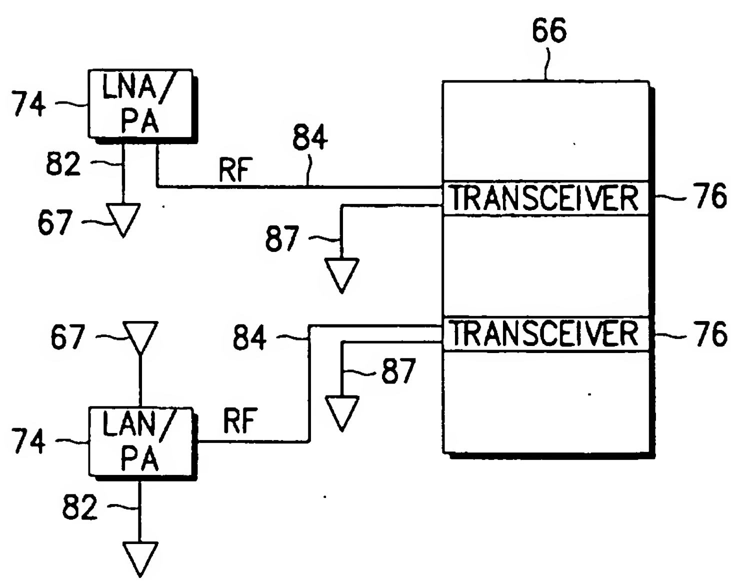
FIG.3
(PRIOR ART)



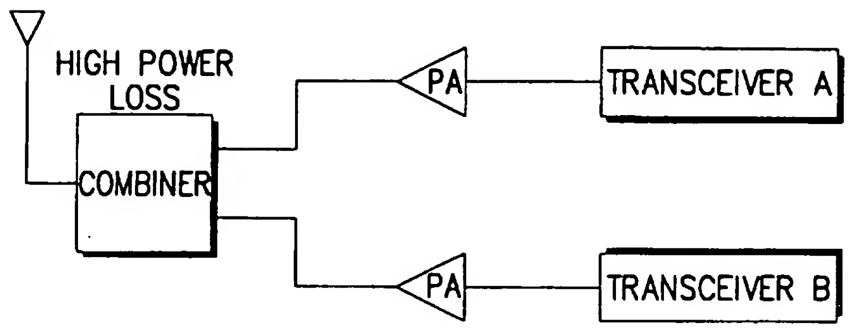
(PRIOR ART)
FIG.4



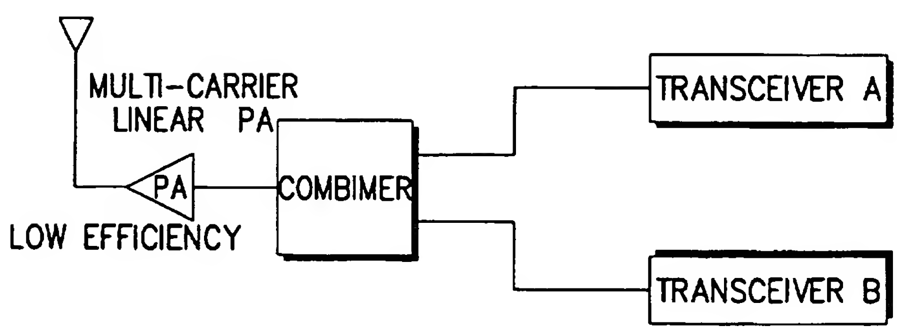
(PRIOR ART)
FIG.5



(PRIOR ART)
FIG.6



(PRIOR ART)
FIG.7



(PRIOR ART)
FIG.8

PICO-BTS ACRONYMS

ACRONYM	FULL NAME
A/D.......	ANALOG TO DIGITAL
AIF........	ANTENNA INTERFACE
ASIC.....	APPLICATION SPECIFIC INTEGRATED CIRCUIT
BBU......	BATTERY BACKUP UNIT
BSC......	BASE STATION CONTROLLER
BSM......	BASE STATION MANAGER
BTS......	BASE TRANSCEIVER SUBSYSTEM
CDMA....	CODE DIVISION MULTIPLE ACCESS
CE-BIT...	CHANNEL ELENENT BUILT-IN TEST
CP.........	COMMUNICATION PROCESSOR
D/A......	DIGITAL TO ANALOG
DCP......	DATA COLLECTION PC
DSP......	DIGITAL SIGNAL PROCESSOR
FPGA....	FIELD PROGRAMMABLE GATE ARRAY
MAP......	MAINTENANCE AND ADMINISTRATION PC
MCU.....	MICRO-CONTROLLER UNIT
MPU.....	MICRO-PROCESSOR UNIT
MSC......	MOBILE SWITCHNG CENTER
MTTF.....	MEAN TIME TO FAILURE
MTTR.....	MEAN TIME TO REPAIR
PCC......	PICO-BTS CHANNEL CARD
PCCM....	PICO-BTS CALL CONTROL MANAGER
PCEM....	PICO-BTS CHANNEL ELEMENT MANAGER
PCM......	PICO-BTS CONFIGURATION MANAGEMENT
PCRM.....	PICO-BTS CALL RESORUCE MANAGER
PFM......	PICO-BTS FAULT MANAGEMENT
PLD......	PROGRAM LOAD DATA
PMCC....	PICO-BTS MAIN CHNNEL CARD
PMU......	PICO-BTS MAIN UNIT
PPM......	PICO-BTS PERFORMANCE MANAGEMENT
PRU.......	PICO-BTS RADIO UNIT
PSA.......	POWER SYSTEM TSSEMBLY
PSLM.....	PICO-BTS SOFTWARE LOAD MANAGEMENT
PSM......	PICO-BTS SECURITY MANAGEMENT
PTM......	PICO-BTS TEST MANAGEMENT
RISC......	REDUCED INSTRUCTION COUNT
SCC......	SERIAL COMMUNICATIONS CONTROLLER
TFC......	TIME AND FREQUENCY CARD
TRIC......	TRANSMIT AND RECEIVE INTERFACE CARD
UART.....	UNIVERSAL ASYNCHRONOUS RECEIVER TRANSCEIVER
XCVR.....	TRANSCEIVER

FIG.9

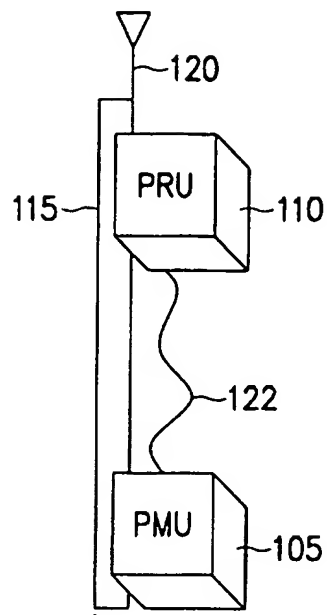

120
PRU
115
110
122
PMU
105

FIG.10

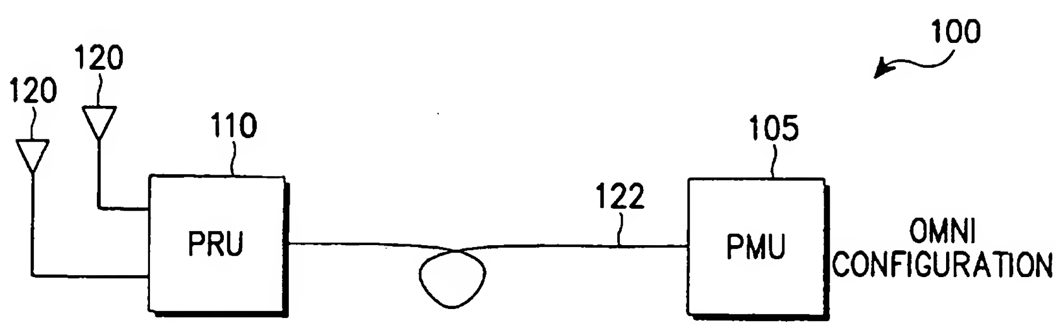

100
120
120
110
105
122
PRU
PMU
OMNI
CONFIGURATION

FIG.11

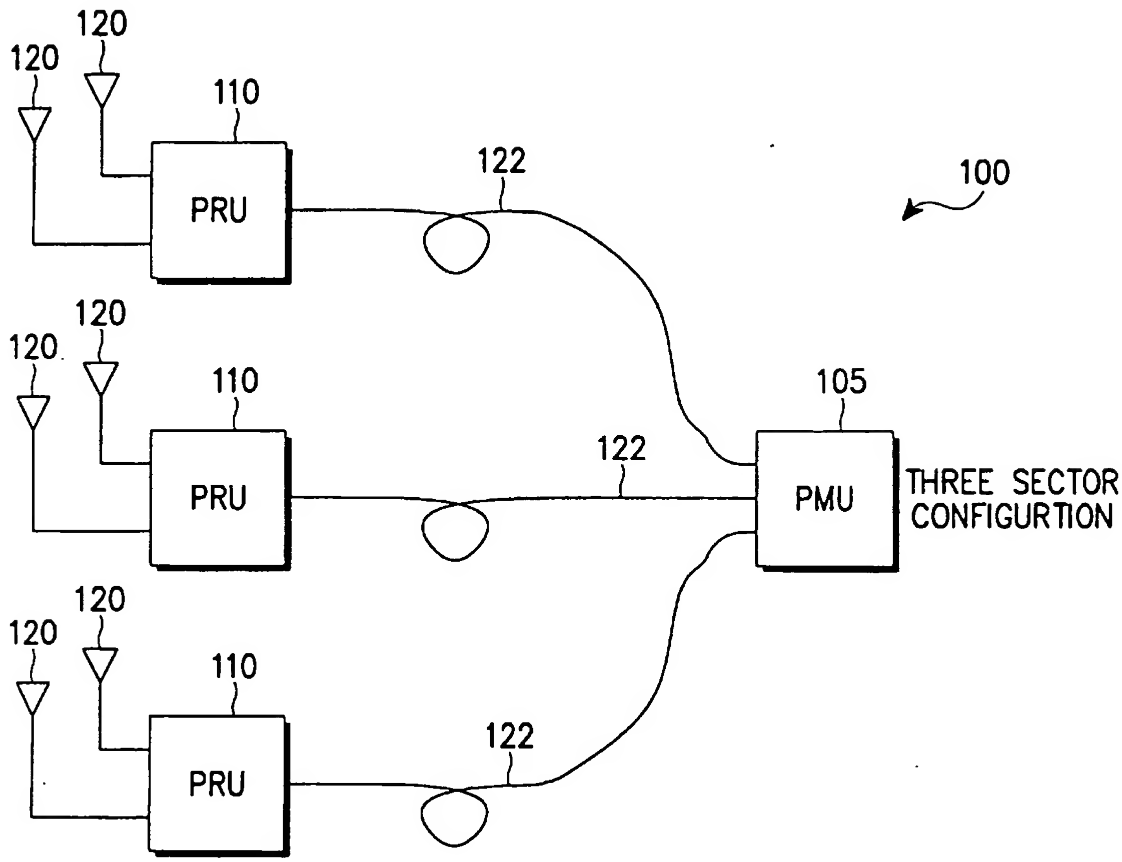
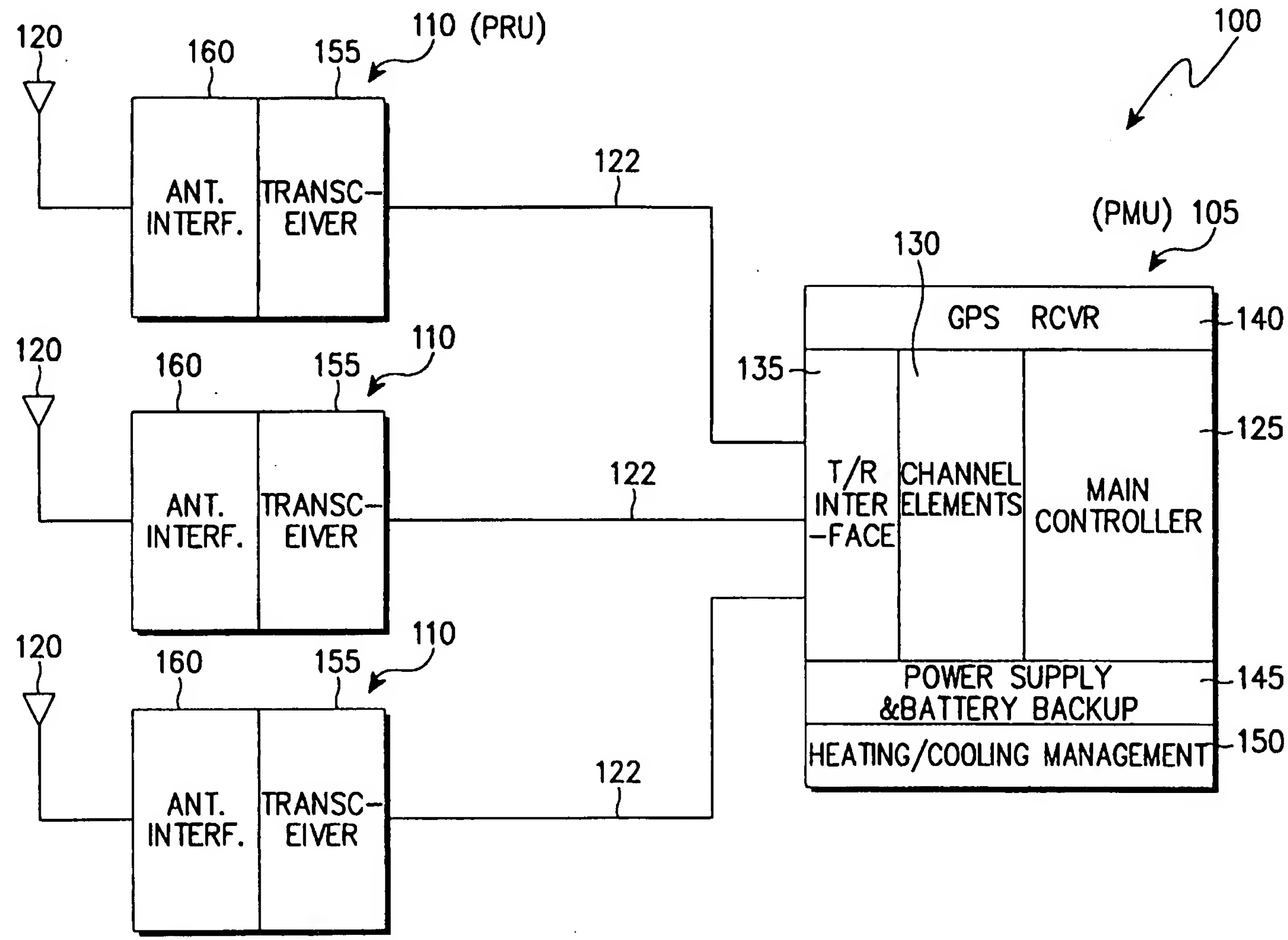

120
120
110
PRU
122
100
120
120
110
PRU
122
105
PMU
THREE SECTOR
CONFIGURTION
120
120
110
PRU
122

FIG.12

FIG. 13



100
110 (PRU)
110
120
160
155
ANT. INTERF.
TRANSC-EIVER
122
(PMU) 105
130
GPS RCVR
140
135
T/R INTER-FACE
CHANNEL ELEMENTS
MAIN CONTROLLER
125
POWER SUPPLY &BATTERY BACKUP
145
HEATING/COOLING MANAGEMENT
150

FIG.14

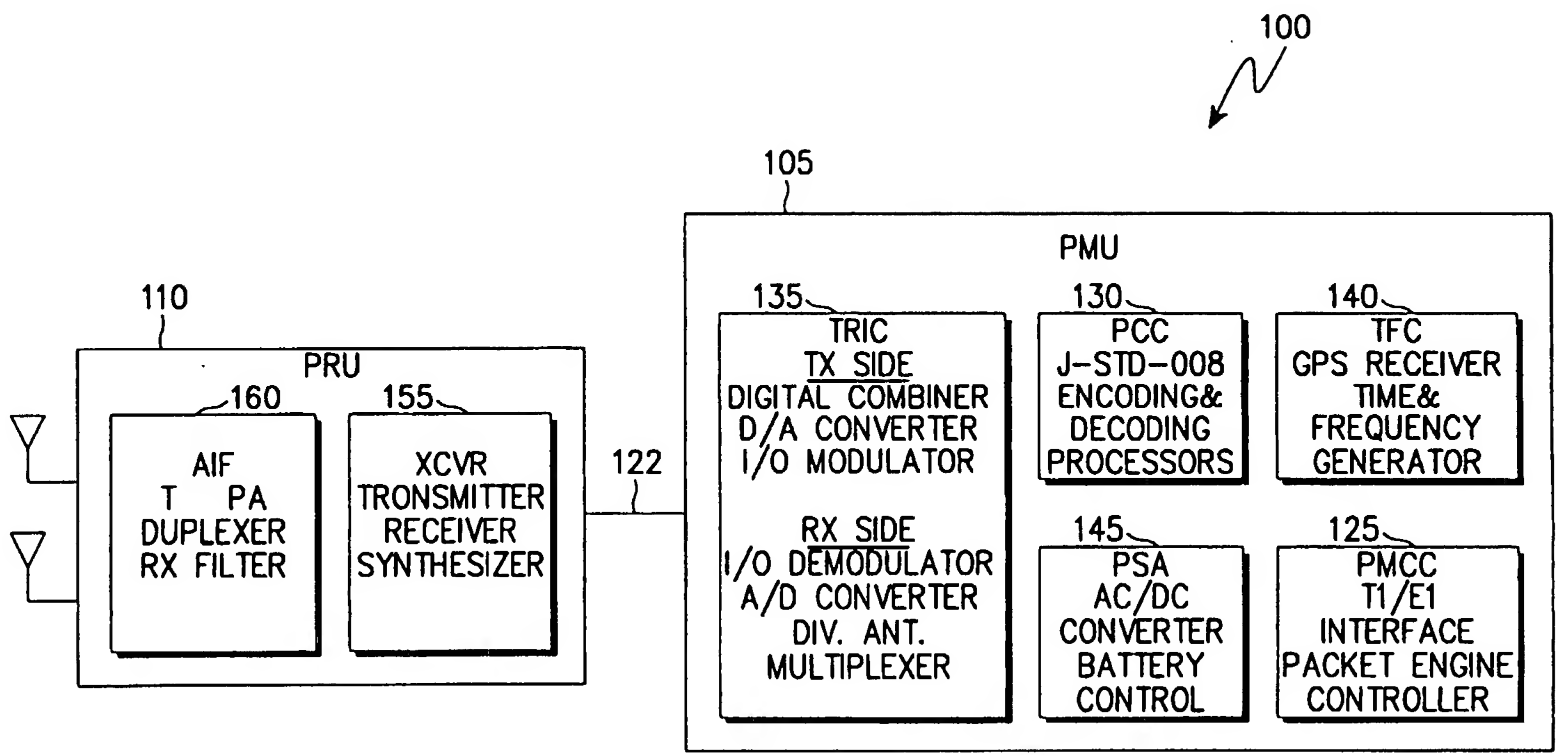
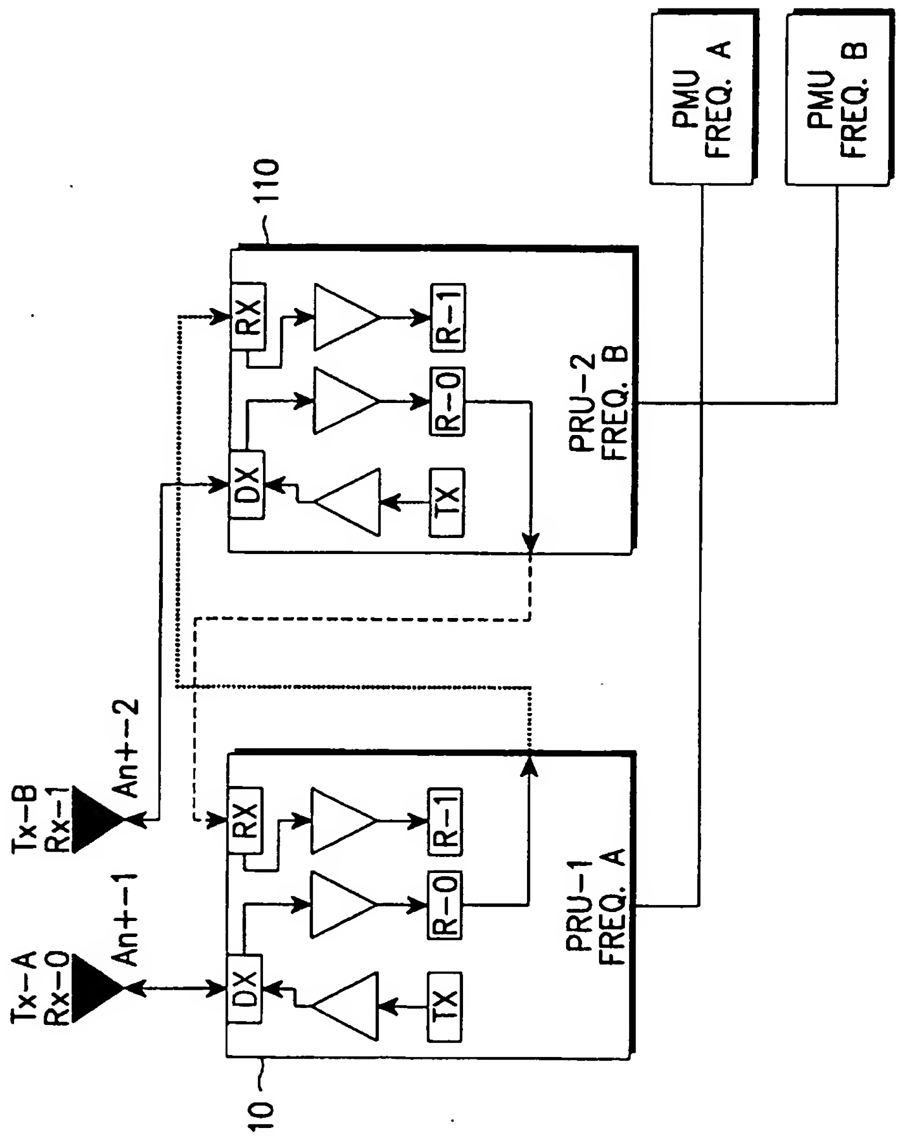

100
105
PMU
135
TRIC
TX SIDE
DIGITAL COMBINER
D/A CONVERTER
I/O MODULATOR
RX SIDE
I/O DEMODULATOR
A/D CONVERTER
DIV. ANT.
MULTIPLEXER
130
PCC
J-STD-008
ENCODING&
DECODING
PROCESSORS
140
TFC
GPS RECEIVER
TIME&
FREQUENCY
GENERATOR
145
PSA
AC/DC
CONVERTER
BATTERY
CONTROL
125
PMCC
T1/E1
INTERFACE
PACKET ENGINE
CONTROLLER
122
110
PRU
160
AIF
T PA
DUPLEXER
RX FILTER
155
XCVR
TRONSMITTER
RECEIVER
SYNTHESIZER

FIG.15



Tx-A
Rx-0
An+--1
Tx-B
Rx-1
An+--2
110
110
DX
RX
TX
R-0
R-1
PRU-1
FREQ. A
PRU-2
FREQ. B
PMU
FREQ. A
PMU
FREQ. B

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A BASE STATION TRANSCEIVER SUBSYSTEM

The present invention generally relates to wireless communication systems and, more particularly, to base station transceiver subsystems used in a Code Division Multiple Access (CDMA) network.

Figure 1 (prior art) is a block-flow diagram which graphically represents a wireless communication system. From figure 1 it is seen that a wireless communication system comprises a mobile station 10, a base station 20, a reverse link 30 which represents the electromagnetic wave communication link transmitted from mobile station 10 to base station 20 and a forward link 40 which represents the electromagnetic wave communication link transmitted from base station 20 to mobile station 10.

Figure 2 (prior art) shows a cell grid and cell sites. In a wireless communication system based on the cellular principle, a service area 49 is divided geographically, into a number of small areas 50, 52, 54, 56 called "cells." In each cell there is a cell site 58, 60, 62, 64 where radio equipment known as a Base Station Transceiver Subsystem (BTS) is installed. Multiple cell layouts such as macro cells, micro cells, and Pico cells can be provided within a particular geographical area to effect hierarchical coverage (where macro cells provide the largest coverage and Pico cells the smallest). Pico cells may be used to provide coverage inside buildings, to cover a special area (campus, stadium, airport and shopping mall), to temporarily cover for special events or areas hit by natural disasters, to cover outlying remote locations, to supplement macro or mini cells with hole-filling, or to enhance the capacity of hot spots.

Figure 3 (prior art) is a block diagram of a wireless system network connected to a land line Public Switched Telephone Network (PSTN) 68. As shown in figure 3, a BTS 66 provides a link to mobile subscribers or (mobile stations) 10. Each BTS 66 typically may include two or more antennas 67, which may be omni antennas or directional antennas. Omni antenna configurations provide 360° of coverage, whereas directional antennas provide less than 360° of coverage across an area known as a sector. For example, there may be two or three sectors in a typical directional configuration such that each sector of a two sector configuration generally provides 180° of coverage and each sector of a three sector configuration generally provides 120° of coverage. For satisfactory reception and transmission, each sector typically requires at least two antennas for diversity reception.

Continuing with the description of figure 3, each BTS 66 is coupled to a Base Station Controller (BSC) 70 (multiple BTSs 66 may be coupled to a single BSC 70). Likewise, each BSC 70 is coupled to a Mobile Switching Center (MSC) 72 and the MSC 72 is in turn coupled to a PSTN 68.

Figure 4 (prior art) is a functional block diagram of a BTS. As shown in figure 4, a conventional BTS 66 typically comprises four major functional blocks for each sector of coverage: an RF front-end 74, a plurality of transceivers 76, a plurality of modem processors 78, and a controller 80. Controller 80 interfaces with a BSC 70 over a T1 or E1 line 81, and the RF front-end 74 is connected to the antennas 67 which are typically mounted at the top of a tower or pole 82 as represented in figure 5 (prior art), where figure 5 illustrates an outdoor and

ground based BTS coupled to a tower top mounted antenna.

In a typical system, the four major functional blocks of the BTS 66, shown in figure 4, are contained in one physical cabinet or housing which is in close proximity to a pole (or tower) 82 at ground level. Long coaxial cables 84 are then run to the top of the pole 82 where the antennas 67 are mounted. The cable length typically varies from 50 to 200 feet, depending on various installation scenarios. Cables of these lengths suffer from undesirable power losses. Accordingly, thick coaxial cable diameters of approximately 0.75"(3/4) to 1"(3/2) are used to minimize the cable power loss, which is typically about 2 to 4 dB. Minimizing these power losses is important because such losses in the cables degrade the receiver sensitivity and reduce transmission power.

Figure 5 depicts a prior art BTS unit 66 connected via a long length of cable 84 to an antenna 67 at the top of a supporting structure 82. Figure 6 (prior art) is a block diagram of yet another known BTS architecture were a tower top mounted RF front-end module consists of a Low Noise Amp (LNA) and a Power Amp (PA) 74 (hereinafter LNA/PA unit 74). The cable power loss in this architecture is not as critical as in the previous mentioned architecture because the power loss can be made up with additional amplification. However, there is still a need to use rather thick cables between the LNA/PA unit 74 and the transceiver 76 in the BTS 66 as the signals are high frequency / radio-frequency (RF) signals. Other problems are associated with transmitted RF signals between the LNA/PA unit 74 and the BTS 66, such as power losses, system noise, and mechanical clutter. Furthermore additional complex circuitry either or both

in the RF front-end module and the transceiver may be required to compensate automatically for the wide range of cable losses that arise in different installation scenarios due to varying cable lengths. Such problems become more severe as the operating RF Frequencies utilise increasingly higher frequency bands. This is the case for personal communications systems such as CPCS.

In other words, as the length of a cable 84 increases, or as the frequency transmitted through a cable 84 increases, power losses between the LNA/PA unit 74 and the BTS 66 increase. Thus, the long cables 84 used to connect the LNA/PA unit 74 to the BTSs 66 (often in excess of 150 feet, sometimes even exceeding 300 feet) introduce large power losses. For example, a 100 W power amplifier in a base station transceiver unit transmits only 50 W of power at the antenna as there is a 3 dB loss in the cable. Power losses in the cable also adversely affect reception by reducing the ability of the receiver to detect received signals. Also, with Personal Communication Systems (PCS) operating at high frequencies, the power loss in the cable 84 running between the LNA/PA unit 74 and the transceiver 76 in the BTS 66 increases. Thus, RF cable losses incurred on both the transmit and receive paths result in poorer than desired transmission efficiency and lower than desired receiver sensitivity, making the use of relatively thick (high conductance) coaxial cables necessary to reduce loss.

Noise generated through ground loops, magnetic coupling, or multi-tower units can cause problems. In these applications, there are usually one or more large coaxial cables which carry RF signals from the antennas 67 to the base station 66. The RF frequencies associated

with such base stations make it difficult to duplex RF signals onto the same coaxial cable, and thus, usually only a single signal is propagated in a single coax cable. Thus, these RF signals are not bundled or duplexed, and therefore require separate cables for each signal and separate connectors for each cable. The RF signal shield of the coax cable 84 is grounded at both ends of the coax cable 84. One end is grounded to the chassis of the BTS, which is grounded to ground 87, whereas the other end of the RF signal shield is grounded through a braid or cable 82 to the chassises of the LNA/PA unit 74. This, unfortunately, creates a ground loop. This ground loop may cause noise in the signal path due to common mode currents adding in phase, and may also cause magnetic coupling. Also, because each tower-top unit generates noise, using multiple tower-top units contributes to noise generation.

In some cell sites where higher capacity is required there is a need to transmit more than one RF carrier signal. The transmission of multiple RF carriers per sector normally would require a corresponding number of transmit antennas per sector, unless a special effort is made to combine multiple RF carriers prior to RF coupling to the antennas. A single set of antennas, per sector, can be shared on the receive side for multiple RF carrier reception.

The conventional technique for reducing the number of transmit antennas required for multiple RF carrier transmission are shown in figure 7 and figure 8. In figure 7 (prior art) the carriers are combined with a high power combiner. In figure 8 (prior art) the carriers are combined at low power and then the combined signal is amplified with a multi-carrier linear power

amplifier.

Neither design is very suitable for use in a compact BTS system. Thus, there is a need for a BTS system which reduces power loss from the BTS to the antennas and is capable transmitting multiple RF carriers per sector/per antenna.

Accordingly, an aspect of the present invention provides A base station transceiver system for a telecommunication system, the base station transceiver system being divided into at least a radio unit for transmitting and receiving telecommunication signals and which can be connected to a first antenna and a main unit, in communication with the radio unit, an interface for communicating with the radio subsystem and a main controller for communicating with a base station controller, the radio and main units being remotely located and communicating using IF or baseband signals.

Advantageously, since the transmission losses between the radio unit and the main unit are less than the losses between radio unit and an antenna, a more efficient system can be realised.

An embodiment of the present invention provides a BTS having a radio unit (RU) located very near to where antenna(s) are mounted, a main unit (MU) connected to, and remotely located from the RU, and one or more antennas coupled to the RU. There can be multiple RUs connected to one MU, which may operate on the same frequency, or at different frequencies.

Furthermore, an exemplary embodiment of the present invention provides a BTS comprising (a) a MU, having a

controller module and channel element modules for base band signal processing of CDMA signals, (b) a RU having a transceiver module, and a power amplifier electrically coupled to the transceiver module and antenna, and (c) a MU connected to a RU via a length of cable carrying low frequency signals (e.g.,. baseband and/or IF signals). The transceiver module in the RU may comprise a transmitter circuit, a receiver circuit and a synthesizer circuit, or a low-noise amplifier (LNA) electrically coupled to the transceiver unit module. The antenna interface module may incorporate a duplexer module, or a power amplifier module and a receiver filter module.

Further, the BTS may comprise: (a) a MU having a channel element module which provides the interface for connectivity to one of the RUs, and (b) a RU having a transceiver module and an antenna interface module.

In addition, the main unit module may further comprise a power system assembly (power supply and battery backup), a time and frequency module, and a temperature management assembly. The RU may also comprise a local controller module and a DC conversion and regulator module. The transceiver module may further comprise transmitter circuitry and two receiver circuits for diversified reception. Furthermore, the RU may incorporate an antenna interface module which may comprise receive filter circuitry and a duplexer circuitry comprising a transmit and receive filter circuit(s) combined into a single cavity.

The present invention provides a BTS consisting of up to three RUs and a MU, whereby the RUs can be remotely located from the MU. The RU primarily comprises a transceiver and an RF front-end. The transceiver, in

turn, comprises an up-converter, down-converter, a synthesizer, a low-noise amplifier and transmit amplifiers. Additionally, the RU comprises an antenna interface unit consisting of a duplexer, a receiver filter and a power amplifier. The MU comprises up to four channel cards, an interface card to RUs, a controller card, a time and reference frequency card, a power system assembly, and a heat management assembly.

The architecture of embodiments of the invention, in essence, separates those of RF elements and dependent elements thereof, which reside in the RU, where there is one RU per sector, from the base band elements and other commonly shared elements thereof, which reside in the MU, supporting up to three RUs.

There are many advantages to this architecture and some of them are as follows.

It results in a compact size RU which can be easily mounted close to the antennas, whereby the cable loss is virtually eliminated. Cable losses degrade the receiver sensitivity and reduce the transmit power. The present invention, thus, allows a relatively low power PA to be used and provides a transmit power level equivalent to a higher power PA used with a conventional BTS.

The inclusion of the transceiver in the RU allows a lower frequency interface, all the way down to DC, rather than RF interface typically used in the prior art, to the MU. The lower frequency interfaces mean low loss in the cable and this allows the use of inexpensive and small diameter interconnect cables between the RUs and the MU.

The separation of RF elements and dependent elements

thereof, also, results in easier adaptation of the BTS design to support different RF operating environments or conditions, such as different frequency bands and different transmission power levels, as only the RU needs to be modified, while the same MU is used. This also results in a compact size MU for ease of handling and mounting, since less space required without the RF elements and, at the same time, less heat load in the MU for cooling.

This architecture also allows the BTS to be configured to support either omni or sector antennas, or to be upgraded from omni to sector operations as the traffic demand increases. This is especially important in CDMA systems where soft handoffs need to be supported between the sectors. For an omni configuration, only one RU is needed. For two or three sector configurations, two and three RUs are needed, respectively. The three RUs can be operated on the same frequency in a three sector configuration or at different frequencies in a three carrier omni configuration.

The present invention also allows the connectivity of another set of three RUs connected to its own MU to the same antennas without the use of a combiner.

Some advantages, features and similar features of the present invention are as follows:

1. By locating the transceiver module in the RU, the only low frequency signals can be passed from the transceiver module to the MU. On the receive side, the transceiver module converts a high frequency signal to a low frequency signal, and on the transmit side, the transceiver module converts a low frequency signal from

the MU to a high frequency signal for transmission. Thus, only relatively low frequency signals are passed between the RU and MU, minimizing power loss in the cables connecting the two units. This results in the ability to use smaller diameter, less costly cables.

2. As the synthesizers are located remotely from the channel processing elements, and ground loops are eliminated, the signals being transmitted and received are subject to far less noise than conventional systems.

3. Another advantage to removing the transceiver subsystem from the MU is that the resulting MU is physically much smaller in size and weighs less. This translates into easier installation and maintenance, as well as into flexibility in meeting the technical demands of a challenging operating assignment or challenging environmental considerations. In addition, smaller size and lighter weight BTSs are especially advantageous for Pico-cell applications or micro-cell applications where a greater number of BTSs are required than are needed for macro cell implementations.

4. With the entire transmit functionality contained in the RU, the RU receives only a baseband signal for transmitted data and performs all of the up-conversion and amplification at the RU. This eliminates the need for transmitting high loss RF signals to the RU, and allows the RU to operate at a higher efficiency than a unit in which the RF signal must travel the length of the pole.

5. As all up-conversion is performed in the RU, direct modulation reduces the complexity of the transmit signal line, and provides a significant cost reduction

over systems that an RF transmit signal up the pole and then up-convert again to RF. Far less RF components are required in the present invention than in the prior art.

6. Output power calibration can be done at the factory and the RU can be programmed for use with any MU. The RU will store full-power settings, as well as reduced power settings, in local memory thus enabling cell size adjustment from the RU, instead of at the BTS.

7. Increased or decreased attenuation can be accomplished in the RU rather than in the BTS.

8. Detection of power control is performed in the RU and, more importantly, can be used to verify the integrity of the entire signal transit path. Previously, in units where the PA is mounted on the pole, the output power attenuation could be detected, but the operator could not determine if the problem was in the PA module or the MU.

9. System upgrades can be accomplished more easily as entire RUs or MUs can be replaced. In addition, because like elements are configured together, board or device level upgrades are also more easily accomplished than with traditional BTS units.

These and other advantages of the present invention will become apparent to one of ordinary skill in the art after consideration of the figures and detailed description which follows hereinafter.

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which

figure 1 depicts a prior art wireless communication system architecture;

figure 2 is a graphical representation of a prior art cell grid and cell sites.

figure 3 is a block diagram of a prior art base station system (BTS) shown connected to a land-line PSTN;

figure 4 is a functional block diagram of a prior art BTS;

figure 5 is an illustration of a prior art ground based BTS coupled to a tower top mounted antenna;

figure 6 is a block diagram of a prior art tower top configuration;

figure 7 is a block diagram illustrating the prior art combiner method for using one antenna to support multiple transceivers;

figure 8 is a block diagrams illustrating the prior art combiner/multi-carrier method for using one antenna to support multiple transceivers;

figure 9 is a list of Pico-BTS acronyms utilized throughout the present application;

figure 10 illustrates a base station system according to an embodiment of the present invention coupled to a pole-mounted antenna;

figure 11 is a block diagram illustrating a base station transceiver subsystem architecture according to an embodiment of the present invention for an omni configuration;

figure 12 is a block diagram illustrating a base station transceiver subsystem architecture according to an embodiment of the present invention for a three sector configuration;

figure 13 is a functional block diagrams of a BTS architecture according to an embodiment of the present invention, with selected subsystems shown;

figure 14 is a modular level block diagram of an

exemplary BTS; and

figure 15 is a block diagram of an alternate embodiment of the present invention of the transceiver/RF front-end module that accommodates two antennas.

In the description which follows, an exemplary preferred embodiment of the invention is described for a Pico base station transceiver subsystem architecture (figure 9 provides a list of Pico-BTS acronyms utilized throughout this application, and which are familiar to those skilled in the art). However, it will be understood that the present invention may be applied to any base station transceiver subsystem architecture in a wireless communication system, including, but not limited to, macro and micro base station transceiver subsystems.

Figure 10 illustrates the basic idea underlying a base station transceiver subsystem (BTS) architecture according to an exemplary embodiment of the present invention. The BTS is separated into two units, the Pico-BTS Radio Unit 110 and the Pico-BTS Main Unit 105. The Pico-BTS comprises the Pico-BTS architecture 100 which is divided into the Pico-BTS Main Unit ("Main Unit System" PMU or MU) 105 which may be located, as shown, at the base of a pole, tower, or other support structure 115, and the Pico-BTS Radio Unit ("Radio Unit System" PRU or RU) 110, which transmits and receives signals through at least one pole-mounted antenna 120, and communicates with the PMU 105 via a plurality of wires 122 which may include a coax cable.

An embodiment of the present invention is illustrated in a high-level block diagram as an omni configuration in Figure 11. PRU 110 can be distally connected to the PMU via wires or cables 122. The

distance or separation between the PRU 110 and the PMU 105 can be from approximately 5 feet to more than 350 feet (current systems are typically separated by about 150 feet). This is adequate since the PMU 105 is designed to be placed at the bottom of a tower building, pole or other supporting structure 115 and the PRU 110 is to be placed at the top of the tower building, pole or other supporting structure near the antenna(s). To transmit and receive signals, the PRU 110 is shown coupled to one of the, but, tower top mounted antennas 120. However, the PRU 110 is typically coupled to at least two antennas.

The wires or cables 122 can include optical cables between the PMU 105 and the PRU 110. Optical cables will increase the distance allowable between the PMU and RMU because an optical signal is less lossy than an electrical signal in, for example, a coaxial cable.

Figure 12 illustrates a BTS architecture according to an exemplary embodiment of the present invention for a three sector configuration. Note that the hardware systems which are required to be duplicated are only duplicated in the PRU 110. Thus, the PMU is capable of interfacing with 1, 2, 3 or potentially more PRU's.

Figure 13 is a block diagram illustrating exemplary elements of the PRU 110 and the PMU 105. It can be seen that the PRU 110 is composed of a transceiver module 155 which is coupled to the antenna interface assembly 160. The antenna interface assembly 160 is coupled to the antennas 120.

The PRU 110 is coupled to the PMU 105 through a set of cables 122 which terminate in the PMU 105 at the

Transmit and Receive interface 135 (T/R interface), which is coupled to the channel elements 130. The channel elements 130 are where the CDMA signal is modulated and demodulated. The PMU 105 may also contain a global positioning receiver 140 which provides accurate clock and frequency signals to a main controller module 125, the channel elements 130, the T/R interface 135, and the PRU(s). Also within the PMU 105 is a power system 145, and a temperature control subsystem 150. Figure 14 provides additional detail of the PRU 110 and PMU 105 subsystems. As shown in figure 14, each PRU 110 essentially comprises two modules: a transceiver module 155 (XCVR) and antenna interface module 160 (AIF). These modules, however, can be combined into one module.

Accordingly, the antenna interface module 160 may include a transmit power amplifier (PA) which amplifies the signal to a level required for desired cell coverage, two low-noise amplifiers (not shown) for amplifying received signals to increase receiver sensitivity, a duplexer module for transmitting to and receiving from a single antenna, and a receiver filter (Rx). The transceiver module 155 may include synthesizer circuitry, transmitter circuitry, and two receiver circuits (it is common to refer to a system's transmitter and receiver circuitry collectively as a "transceiver").

The PRU 110 also includes a microprocessor and non-volatile memory (not shown) to store calibration data and provide real-time temperature operating parameter compensation to the transceiver. Thus, a mobile station or mobile simulator is not needed for calibration, and system calibration in the field is also no longer needed.

PRU 110 preferably houses the duplexer and the

receive filter in a common cavity. This is essentially three filters (two receive and one transmit) combined into one aluminium cavity. By combining the prior art duplexer cavity with the prior art diversity receive cavity, valuable space inside the unit may be used for other circuitry and cost is further reduced.

In the preferred exemplary embodiment, the duplexer/receiver filter cavity of PRU 110 is designed so that the connectors on the filter protrude directly through the cover of the unit, eliminating any coaxial cable bulkhead connectors. This approach requires fewer parts in the unit, again saving valuable space and reducing cost.

As illustrated in figure 14, the PMU 105 includes six functional subsystems: a Pico-BTS main controller card 125 (PMCC), a Pico-BTS channel card 130 (PCC), a transmit and receive interface card 135 (TRIC), a time and frequency card 140 (TFC), and a power supply assembly 145 (PSA) for converting AC to DC and for distributing the DC power throughout the PMU 105 and the PRU 110. The temperature management subsystem 150 is not shown in figure 14 to simplify the figure.

In operation, the PMCC 125, which includes an external interface module and a communications controller module, often called a packet engine, monitors all of the cards in the BTS architecture 100 and routes traffic and signaling packets between a Base Station Controller (BSC, see figure 3) shown) and the PCCs 130. Likewise, the TRIC 135 provides the interfaces between the transceiver module 155 and the PCCs 130. The TRIC provides the connectivity to the PRU 110 through interconnect cables 122.

Base-band analog signals and intermediate frequency (IF) signals in the frequency range of about 1 kHz to about 700 MHz are propagated in cables 122 connecting PMU 105 with PRU 110. The preferred IF frequency range is 239 MHz with a 1.26 MHz bandwidth and a signal strength of between -50 dBm and -70 dBm. The advantage of this approach is that the modulated signals can be duplexed and sent through a standard, inexpensive RG-58 coaxial cable. Other signals to be carried between the units include 48V power, a 10 MHz reference, and RS-422 control lines.

The separation of the PRU 110 and the PMU 105 allows the PRU 110 to be installed close to the antennas 120. Since in practice power losses in the antenna cable degrade receiver sensitivity and reduce the transmit power at a 1:1 ratio (dB per dB), locating the PRU 110 in close proximity to the antenna 120 increases the performance of the BTS 100. The location of the PRU also reduces power and signal losses through a cable and thereby may save energy.

It is worth noting that all wires and coaxial cables may be bundled into a single polymer jacket. Thus, a single multi-wire/coaxial connector is used at both ends of the cable. The resulting cable is typically built as a unitary item which provides ease of installation and repair in the field. Thus, the cable diameter may easily be kept under 0.75 inches, providing easy installation in the field, as well as in an indoor applications (which require turning corners).

Coaxial cables coming into PRU 110 are transformer coupled to the transceiver, which eliminates the possibility of ground loops (and their corresponding

ground noise), and ensures that the PRU 110 can be placed up to and in excess of 150 feet away from PMU 105. In addition, if the PRU 110 is connected to a pole or other conductive structure which is grounded, there will be no system performance degradation due to noise coupling. Power, at 24 or 48 VDC or an AC voltage, is sent to the tower top with a separate return. This provides less power loss in the power wires, making the system more efficient.

The signals carried by the cable 122 between PMU 105 and PRU 110 operate efficiently over a range of about 1 kHz to 240 MHz. This results in low signal attenuation, even when using thin, low cost cables.

Figure 15 depicts an exemplary embodiment whereby two PRUs 110 provide an additional means of connectivity such that only two antennas are required with two PRUs for dual frequency carrier operation. As shown, both antennas are connected to the duplexer (DX) ports of the PRUs. In a single RF carrier operation, antenna 1 (Ant-1) would transmit and receive one diversity signal (Rx-0), and the other antenna would receive only the other diversity signal (Rx-1). In a dual carrier operation in either omni or sector configuration, both antennas transmit, i.e., Ant-1 transmits Freq. A from PRU-1 and Ant-2 transmits Freq. B from PRU-2, and at the same time both antennas receive one diversity signal each. One receive diversity signal Rx-0 is received and the other receive diversity signal Rx-1 comes from the other antenna Ant-2 indirectly through the other PRU after it has been pre-amplified to increase or maintain the receive sensitivity. This diagram does not necessarily reflect the actual implementation, as there can be many different possibilities with different advantages and

disadvantages. This technique thus allows the addition of a second RF carrier for higher capacity operation without requiring additional antennas.

While the invention has been particularly shown and described with reference to specific embodiments thereof, it will be understood by those skilled in the art that various changes in form and detail may be made thereto, and that other embodiments of the present invention, beyond embodiments specifically described herein, may be made or practiced without departing from the spirit and scope of the present invention as limited solely by the appended claims.

CLAIMS

1. A base station transceiver system for a telecommunication system, the base station transceiver system being divided into at least a radio unit for transmitting and receiving telecommunication signals and which can be connected to a first antenna and a main unit, in communication with the radio unit, an interface for communicating with the radio subsystem and a main controller for communicating with a base station controller, the radio and main units being remotely located and communicating using IF or baseband signals.

2. A base station transceiver system as claimed in claim 1, in which a main unit further comprises at least one channel circuit for modulating and demodulating CDMA signals exchanged with the radio unit.

3. A base station transceiver system as claimed in either of claims 1 and 2, in which a main unit further comprises a temperature management system to control heat generated by other components of the main unit.

4. A base station transceiver system as claimed in any preceding claim in which the main unit further comprises a global positioning unit connected to the main controller.

5. A base station transceiver system as claimed in any preceding claim in which the interface can receive demodulated telecommunication signals that were

received and demodulated in the radio unit.

6. A base station transceiver system as claimed in any preceding claim which handles CDMA communications such that the main unit converts land line telecommunication signals to a CDMA signal and the radio unit modulates the CDMA signals for transmission via the first antenna.

7. A base station transceiver system as claimed in any preceding claim in which the radio includes a radio transceiver portion comprising a transceiver circuitry and an antenna interface circuitry connected to the transceiver circuitry.

8. A base station transceiver system as claimed in claim 7 in which the antenna interface circuitry comprises a transmit power amplifier which provides an amplified signal to a first antenna.

9. A base station transceiver system as claimed in either of claims 7 and 8 in which the antenna interface circuitry comprises at least one low-noise amplifier for amplifying received signals.

10. A base station transceiver subsystem as claimed in any of claims 7 to 9 in which the antenna interface circuitry includes duplexer circuitry for allowing the transmission reception of signals to and from the first antenna.

11. A base station transceiver system as claimed in any of claims 7 to 10 in which the antenna interface circuitry interfaces to the first antenna and a second antenna.

12. A base station transceiver system as claimed in any of claims 7 to 11 in which the transceiver circuitry comprises a transmitter circuit for transmitting signals via the first antenna and at least a first receiver for receiving signals from the first antenna.

13. A base station transceiver as claimed in any of claims 7 to 12 in which the transceiver circuitry further comprises a synthesiser for setting the transmit and receive frequencies and a communication link for communicating between the radio unit portion and the main unit portion.

14. A base station transceiver system substantially as described herein with reference to and/or as illustrated in any of figures 10 to 15.

Application No: GB 9930250.7
Claims searched: 1-14

Examiner: Robert Macdonald
Date of search: 21 June 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): H4L(LDDSX, LDRS, LEQF, LECY)

Int Cl (Ed.7): H04Q(7/30, 7/36)

Other: ONLINE: WPI, PAJ, EPODOC

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X,E	EP 0938241 A2	(LUCENT TECHNOLOGIES) See figure 4 and abstract.	1, at least
Y	EP 0749252 A2	(NEC) See whole document.	4
X	EP 0600681 A1	(AT & T) See whole document.	1,5,7,8,9
X,E	WO 99/44297 A2	(ADICOM WIRELESS INC) See claim 1 and abstract.	1,8,10
X,Y	WO 96/27269 A1	(NOKIA TELECOMMUNICATIONS) See figure 1, especially.	X (1,5,7, 11,12) Y(3,4)
X	US 5768685	(HUGHES ELECTRONICS) See whole document.	1,5,7,8,9, 11,13.
X	US 5680438	(AT & T) See figure 1, especially	1, at least
Y	JP 050292002	(NEC) See enclosed abstracts.	3

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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